CA2ALZ 3
74I01
c.1

CA2 ALZ 3 1974I01
Report by the Alberta Industry Governmen
t Sour Gas Environmental Committee 1
3 3398 00145 9550

A REPORT BY THE

ALBERTA INDUSTRY GOVERNMENT

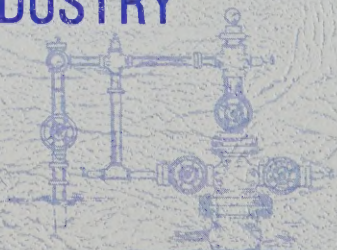
SOUR GAS ENVIRONMENTAL COMMITTEE

ON

GUIDELINES FOR URBAN DEVELOPMENT

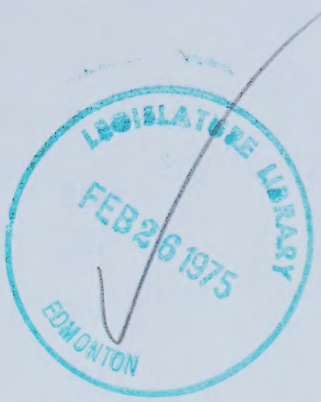
IN

RELATION TO THE SOUR GAS INDUSTRY



OCTOBER, 1974

Digitized by the Internet Archive
in 2026 with funding from
Legislative Assembly of Alberta - Alberta Legislature Library



A REPORT BY THE

ALBERTA INDUSTRY-GOVERNMENT SOUR GAS ENVIRONMENTAL COMMITTEE

ON

GUIDELINES FOR URBAN DEVELOPMENT

IN RELATION TO THE SOUR GAS INDUSTRY

October, 1974

TABLE OF CONTENTS

Section		Page
1	INTRODUCTION	1-1
2	CONCLUSIONS	2-1
3	RECOMMENDATIONS	3-1
4	DISCUSSION	4-1
	4.1 Past History of Sour Gas Releases	4-1
	4.2 Sour Gas Inventory for Alberta	4-2
	4.3 Toxicology of Hydrogen Sulphide and Sulphur Dioxide	4-6
	4.4 Regulatory Matters	4-8
	4.5 Dispersion Calculations	4-12
	4.6 Examples of Sour Fields Near Urban Development	4-14
5	TABLES	
	Table 1	5-1
	Table 2	5-2
	Table 3	5-3
	Table 4	5-7
	Table 5	5-9

Digitized by the Internet Archive
in 2026 with funding from
University of Alberta Library

https://archive.org/details/ableg_33398001459550

1 INTRODUCTION

1.1 Statement of the Problem

The Alberta Industry-Government Sour Gas Environmental Committee consists of representatives from Alberta Environment, The Energy Resources Conservation Board, Environment Canada, and the Alberta oil and gas industry. In a meeting of this committee in early 1974, industry committee members expressed concern over the lack of regulations or policies to adequately control the encroachment of population centres on to sour gas operations. Ever expanding population centres are continuing to infringe upon these hydrogen sulphide containing fields, yet for planners, developers and others there exists a distinct lack of information about the hazards associated with sour field operations. In view of this fact an Urban Encroachment Sour Gas Subcommittee was formed to study this problem and issue a report examining the present problems associated with sour gas operations near population centres and making recommendations for further action. The members of the subcommittee were Mr. E. E. Kupchanko of Alberta Environment, Mr. E. R. Brushett of the Energy Resources Conservation Board, and Mr. R. S. Geddes of Canadian Occidental Petroleum Ltd. The subcommittee was also assisted with technical advice from other industry and government personnel.

1.2 Purpose of the Report

The purpose of this report is three-fold. The first is to determine the degree of the urban encroachment problem and to catalog the existing regulations for the protection of the public against sour

gas releases. The second purpose of the report is to serve as a basis for future regulations or policies regarding the development of residential areas in or near sour fields. Finally, this report is intended to serve as basic information on the subject for parties involved in urban planning or development.

2 CONCLUSIONS

The conclusions drawn by the subcommittee from this study are as follows

(1) There are generally a large number of populated settlements in Alberta encroaching upon sour gas operations, especially in the area between Calgary and Edmonton. Uncontrolled gas releases from these fields could pose a hazard to large numbers of the residents,

(2) The past history of sour gas releases from petroleum industry operations shows the frequency of such uncontrolled releases to be low at the present time,

(3) There is a need for examination of this problem by urban planners and developers before residential districts are constructed near sour fields. This is an area where little information is available at present, and

(4) Insufficient regulations or procedures exist at the present time to adequately control the encroachment of population centres on sour oil and gas operations.

3 RECOMMENDATIONS

The Alberta Industry-Government Sour Gas Environmental Committee recommends that

(1) In general, no new subdivision developments be permitted within a 100 parts per million hydrogen sulphide isopleth of any sour gas operation,

(2) All proposed new developments of the type mentioned in recommendation (1) and located in the shaded areas shown on Map One or located near any other sour gas operation be referred to the Energy Resources Conservation Board for comment respecting the likelihood that the development will fall inside the 100 parts per million isopleth, and

(3) Appropriate legislation or mechanisms be enacted so as to limit any other human habitation in proximity to sour gas facilities.

4 DISCUSSION

4.1 Past History of Sour Gas Releases

Past history in the oil and gas industry has shown that there are two probable sources from which large volumes of sour gas may escape. Pipe line breaks in sour gas gathering or transmission lines are one such source. The second is blowouts emanating from gas or oil wells during drilling or servicing operations. Blowouts, such as the one which occurred in the Malmo field near New Norway in 1973, are less frequent than pipe line ruptures. Tables 1 and 2 give a previous Alberta history of sour gas pipe line breaks for the last 4 years and of sour well blowouts for the past 5 years.

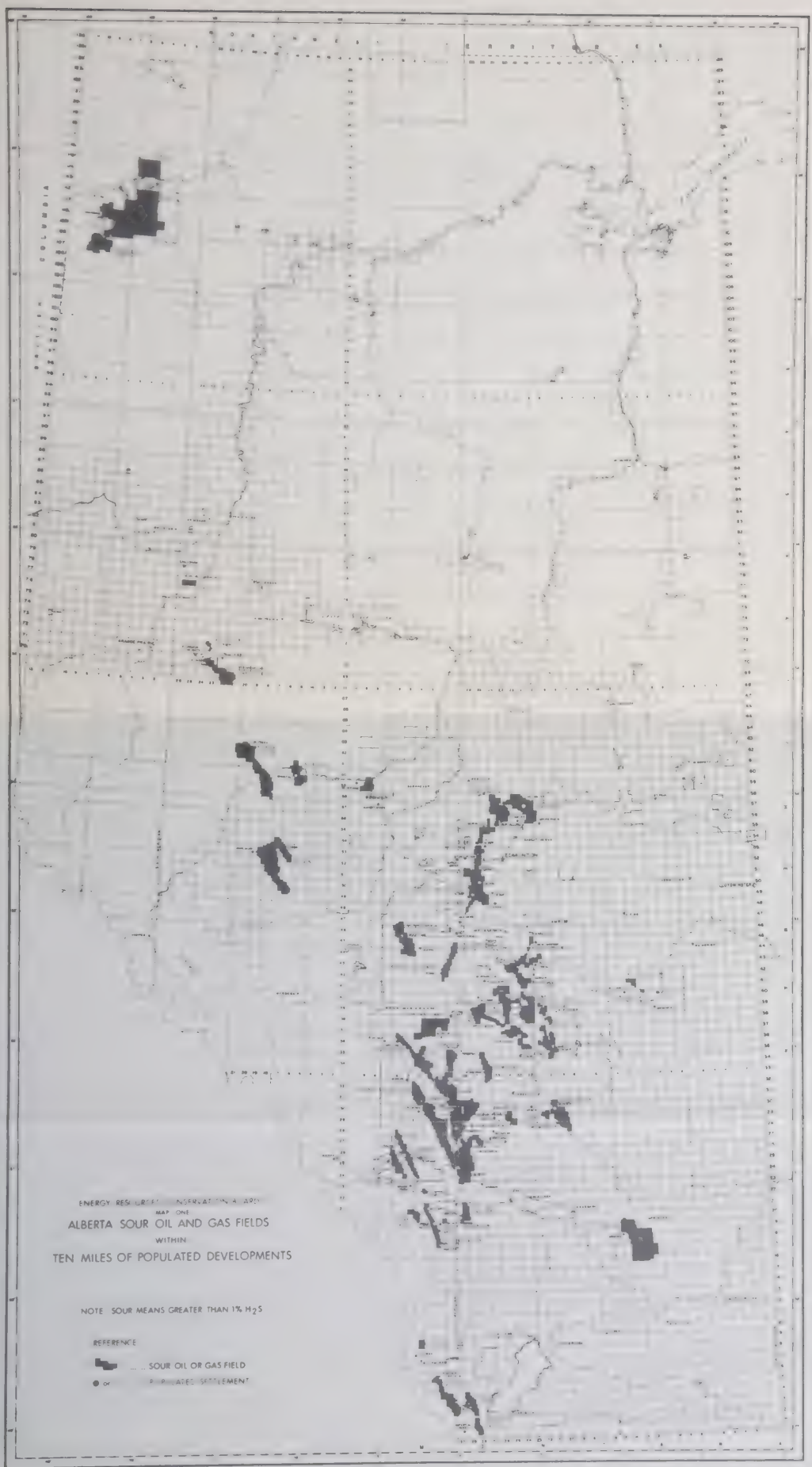
From Table 1 it can be seen that the number of sour pipe line breaks for the past 4 years has averaged about seven per year. Over 85 per cent of those breaks have been due to internal corrosion resulting from the action of hydrogen sulphide and water on steel pipe. Breaks due to this type of corrosion are generally very small, often of the pin-hole size, and the rate of gas released is not rapid. Substantial volumes of sour gas may escape, however, over a long period of time and often these are not detected due to the lack of sensitivity of any leak detection facilities. Leaks of this type may result in high hydrogen sulphide concentrations in the immediate vicinity of the break but seldom present hazards to habitation over 100 feet away. On the other hand, breaks due to line punctures from ditchers or sudden pipe line failures from faulty or damaged pipe often result in much higher gas release rates and higher total volumes of sour gas released. This type of break accounts for the other 15 per cent of the total. In

these cases large land areas may be exposed to dangerous hydrogen sulphide concentrations depending on the release rate, H_2S concentration and the dispersion characteristics of the gas plume.

Table 2 shows a 5 year history of sour well blowouts in Alberta. It is evident that the number of sour well blowouts is much smaller than the number of sour gas pipe line breaks - these blowouts average about one per year out of a total of over 3,700 sour oil and gas wells in the Province. However, the gas release rate may be considerably higher in these situations and the duration of the escape is likely to be much longer. Thus while the probability of a sour well blowout occurring is considerably less than a pipe line break, the degree of associated danger to human settlement is sometimes equal to or higher than that associated with a pipe line break.

4.2 Sour Gas Inventory for Alberta

There are over 100 sour oil and gas fields in the Province of Alberta. Of these, 75 are located within 10 miles of a city, town or village and as such may be considered to present a possible hazard to those settlements. Sour oil fields seldom produce as much gas in conjunction with the oil as is produced from sour gas fields. Since the danger created by downwind hydrogen sulphide concentrations is directly proportional to the volumetric escape rate of H_2S, sour oil fields should be classified in most cases as less of a hazard than sour gas fields. The locations of the 75 fields near populated development are shown on Map One of this report. Table 3 gives a breakdown of each field, indicating whether it is oil or gas, the percentage H_2S and any nearby population centres.


ENERGY RESOURCES CONSERVATION BOARD
MAP ONE
ALBERTA SOUR OIL AND GAS FIELDS
WITHIN
TEN MILES OF POPULATED DEVELOPMENTS
NOTE SOUR MEANS GREATER THAN 1% H_2S
REFERENCE
SOUR OIL OR GAS FIELD
POPULATED SETTLEMENT

From Map One it can be seen that the most congested area in Alberta in terms of sour fields, lies along a 50-mile-wide corridor between Calgary and Edmonton. Unfortunately this is also one of the most densely populated areas in the Province. Many large settlements such as Calgary, Olds, Red Deer, Devon and Edmonton are inside or bordered by one or more sour fields. Within this larger corridor, there are two areas of particular concern - the fields just north of Calgary and those east of Red Deer. Both these areas contain high H_2S percentage wells capable of producing large volumes of gas. Other areas in the Province, such as the Rainbow - Zama area in Northern Alberta may be considered of relatively low hazard since the area is, for the most part, sparsely populated. Sour fields which are beyond 10 miles from populated settlements have been omitted from this map.

In order to better analyse the degree of hazard associated with sour wells and from sour gas pipe line breaks, a data survey has been done on a number of sour fields in the Province. Of prime interest in this survey was determining what volumes of pure hydrogen sulphide could escape from wells or pipe lines containing sour gas. This information could then be used in dispersion calculations assuming the worst case conditions.

When a well bore is completely exposed to the atmosphere, as could occur if the well head were sheared off, the flow rate of gas escaping from the well will be related to its absolute open flow (AOF) potential. The AOF of a gas well is a theoretical calculation of the flow that would be possible if the pressure at the bottom of the well bore was equal to zero. The actual deliverability of a well under these conditions will be less than the AOF due to frictional losses in the

tubing, non-zero bottom-hole pressure and other factors. However, in the event that down-hole safety valves are not installed or that they fail to close, the gas escape rate of average productivity wells should roughtly approximate their AOF. Higher productivity wells would have an escape rate somewhat less than their AOF. It should be noted that this will provide the worst case possible since, if safety valves close or the well bore is only partially exposed to the atmosphere, the escape rate of gas will be reduced.

The combination of gas flow rate multiplied by percentage hydrogen sulphide to give the pure hydrogen sulphide escape rate is the primary indicator of the lethal capacity of a sour gas well. The average AOF values of sour wells in the surveyed producing fields range from about 1 to 150 million cubic feet per day. Average hydrogen sulphide concentrations for these pools range from 1 to 50 per cent H_2S. These two conditions result in pure hydrogen sulphide flow rates from less than one to over 40 million cubic feet per day. The Ricinus West, Waterton, and Kaybob South gas fields are among the highest producers of hydrogen sulphide. However, the duration of gas escape from any blowout is dependent mainly on the particular conditions and procedures required to stop the blow.

Gas escapes from pipe line ruptures tend to be of much shorter duration than blowouts, although the gas escape rate may be higher for that short period of time. A survey of some of the major operators of sour gas fields in Alberta showed that for the worst case, break releases could produce up to an initial instantaneous rate of 70 million cubic feet per day of pure hydrogen sulphide, with an average

being about 10 million per day. Most large sour gas gathering systems, however, have line break detection equipment which activates pipe line block valves in the event of a large rupture. The reaction time for most of these systems to sense a rupture and shut the valve is generally 1 to 3 minutes. Once the valves are closed the wells can no longer feed the damaged section of the line but there is still a significant volume of gas left in the isolated section. It appears that in most cases the sour gas will continue to escape for 20 to 30 minutes until the line pressure reaches atmospheric pressure. Gas gathering systems with no automatic line break detection equipment could release sour gas for much longer periods of time depending on how long the break remained undetected, and once detected, how long it would take for an operator to manually shut-in the system.

4.3 Toxicology of Hydrogen Sulphide and Sulphur Dioxide

4.31 Hydrogen Sulphide

Before any consideration is given to the health effects of hydrogen sulphide, it should be noted that the effects do not necessarily apply to all persons exposed as effects can vary with the individual's health history. Concentration is more important than duration of exposure. The following information was obtained from the Alberta Environment report on the New Norway sour gas escape.

Hydrogen sulphide has a characteristic (rotten egg) odour which is detectable at approximately 0.3 ppm (parts per million). As the level increases, the odour becomes more pronounced up to about 20 ppm. Over 25 ppm the odour diminishes, due to fatiguing (and later paralysis) of

the sense of smell. The gas is highly irritant to the eyes. It produces conjunctivitis (red eye), keratitis (inflammation of the cornea) after prolonged exposure and in some instances, photophobia (increased sensitivity to light). Adsorption through the skin is negligible and the main hazard is from inhalation. Once in the body, hydrogen sulphide is rapidly oxidized to form various compounds of low toxicity. Hydrogen sulphide oxidation products are eliminated through the intestines, kidney and to a lesser degree through the expired air. The effect produced depends mainly on the combination of levels of exposure and the time over which the exposure or exposures occur.

Aside from its direct irritant action on the eye and mucous membranes, the gas exerts its main effect on the respiratory process. Hydrogen sulphide inhibits the activity of the respiratory enzyme cytrochrome oxidase, by making the iron in the substance no longer available and thus blocking the cellular oxidation/reduction process. Interference with the respiratory process at the cellular level produces tissue anoxice.

Hydrogen sulphide may form small quantities of sulphides, each with varying degrees of tissue toxicity. These enter the general circulation and by their action on specific centres may give rise to increased respiration rate, and slowing of heart rate. Hydrogen sulphide also inhibits the enzymes catalase and peroxidase.

The effects of hydrogen sulphide on humans for a range of H_2S concentrations is shown in Table 4.

4.32 Sulphur Dioxide

Sulphur dioxide also causes adverse reactions in exposed human beings. The effects of sulphur dioxide in humans for a range of SO_2 concentrations is given from F. A. Patty in Table 5.

The accepted permissible limit for prolonged exposure as set by the Workman's Compensation Board of Alberta is 5 ppm. Fifty to one hundred ppm is considered the maximum permissible amount for 30 to 60 minutes exposure, while 400 to 500 ppm is immediately dangerous to life. Men are not likely to voluntarily enter concentrations high enough to be immediately harmful.

4.4 Regulatory Matters

The Energy Resources Conservation Board administers a number of acts and regulations designed to protect the populace from the hazards of sour gas. In the design of pipe lines carrying any types of gas, the Board requires that the Canadian Standards Association Code Z 184 be followed. Section 6.2 of this code specifies several classes which are to be applied to the class location unit - an area that extends 220 yards on either side of the pipe line. Classes 1 to 4 are defined by the population density and/or the type of structures located within the unit. The higher the class location, the more stringent the pipe line design criteria. Should the class of an area change due to population influx, the operator of the pipe line is still required to ensure that the line meets the required specifications. This provision does not differentiate between sweet and sour gas.

Section 2.110 of the Oil and Gas Conservation Regulations provides some distance protection to residences in the proximity of a new well.

It states that no well shall be drilled at any point which is within 330 feet of any surface improvements except under special conditions. It does not, however, require new residences to stay beyond 330 feet of an existing well.

Section 7.050 applies to wells which produce gas with a hydrogen sulphide concentration of greater than 5 per cent. Unless it is produced by artificial lift, the well must be equipped with two master valves and a production packer with the annular space between tubing and production casing filled with a corrosion inhibited liquid. Except when the well has an operating flow line pressure below 200 psig, the well head must be equipped with a valve which closes automatically in the event of an uncontrolled flow of oil or gas. Also, if the well is located within one-half mile of an occupied dwelling or within 5 miles of a city, town or village, and has the potential to produce 5 million cubic feet per day of gas, it must be equipped at a depth of over 100 feet with a surface controlled shut-off valve which closes automatically in the event of a blowout. The Board also requires some operators to file an outline of the emergency procedures which will be followed in the event of an uncontrolled release to ensure public safety.

Section 8.190 simply states that an operator shall not permit a well to flow uncontrolled without attempting to control it, and that in the event of such an uncontrolled release the Board must be notified by the quickest effective means.

Emergency procedure organization in the event of a release of sour gas from gas processing plants is required by Section 9.060. Similarly, the Board's Pipe Line Department requires that emergency

procedures be set out in the case of an escape of gas from a sour gas pipe line.

At the present time there are no Board regulations which control the encroachment of urban or rural development on sour oil or gas facilities.

The Alberta Department of Municipal Affairs has but one regulation restricting subdivision activity near any oil or gas facility. Section 37 of The Subdivision and Transfer Regulations states that where any pipe line as defined in The Pipe Line Act crosses or is situated in the vicinity of land which an applicant proposes to subdivide, the subdivision shall be designed

(a) so that the pipe line is located within the right of way or parallel to and alongside a quarter section line or the right of way of a public roadway or lane, and

(b) so that no habitable building on any parcel so created in the proposed plan of subdivision shall be sited closer than 50 feet to the centreline of the pipe line, and

(c) so that a parcel to be created that is adjacent to or abutting a pipe line right of way shall not be less than 150 feet in depth.

There are also government regulations currently in effect in France, near the sour Lacq field. Below are the regulations regarding Construction of Production and Processing Installations in rural areas.

(a) Conditions of Land Utilization - Construction Not Permitted

In a rural zone, the only type of construction permitted are agricultural facilities and installations necessary for the production and transportation of Lacq gas. Construction of all dwellings is prohibited. However, the following can be approved

i. An isolated non-agricultural house, if this construction does not disturb the agricultural economy, and if this construction would not be detrimental to future urban spread or result in a cost increase for public services.

If such house construction is permitted, it will be on a 2000 square meters lot. This area can be decreased to 1000 square meters if the house can be connected to a public water supply system.

ii. Installation in the public interest such as telephone and power supply.

(b) Limits on Construction in the Vicinity of Wells and Flow Lines

No construction is permitted within 600 meters of a well. Under special circumstances, wells have been drilled within 600 meters of the village limits of Lacq, Artix, Lagor, Arganon and Mourenx.

No construction is permitted within 50 meters of a sweet gas pipe line.

For large diameter pipe lines, the distance may be greater than 50 meters at the discretion of the Mines Inspection Engineer based on public security.

(c) Limits Imposed on SNPA and Others for the Exploitation of the Lacq Gas Fields

Installations for processing and transportation of gas, and

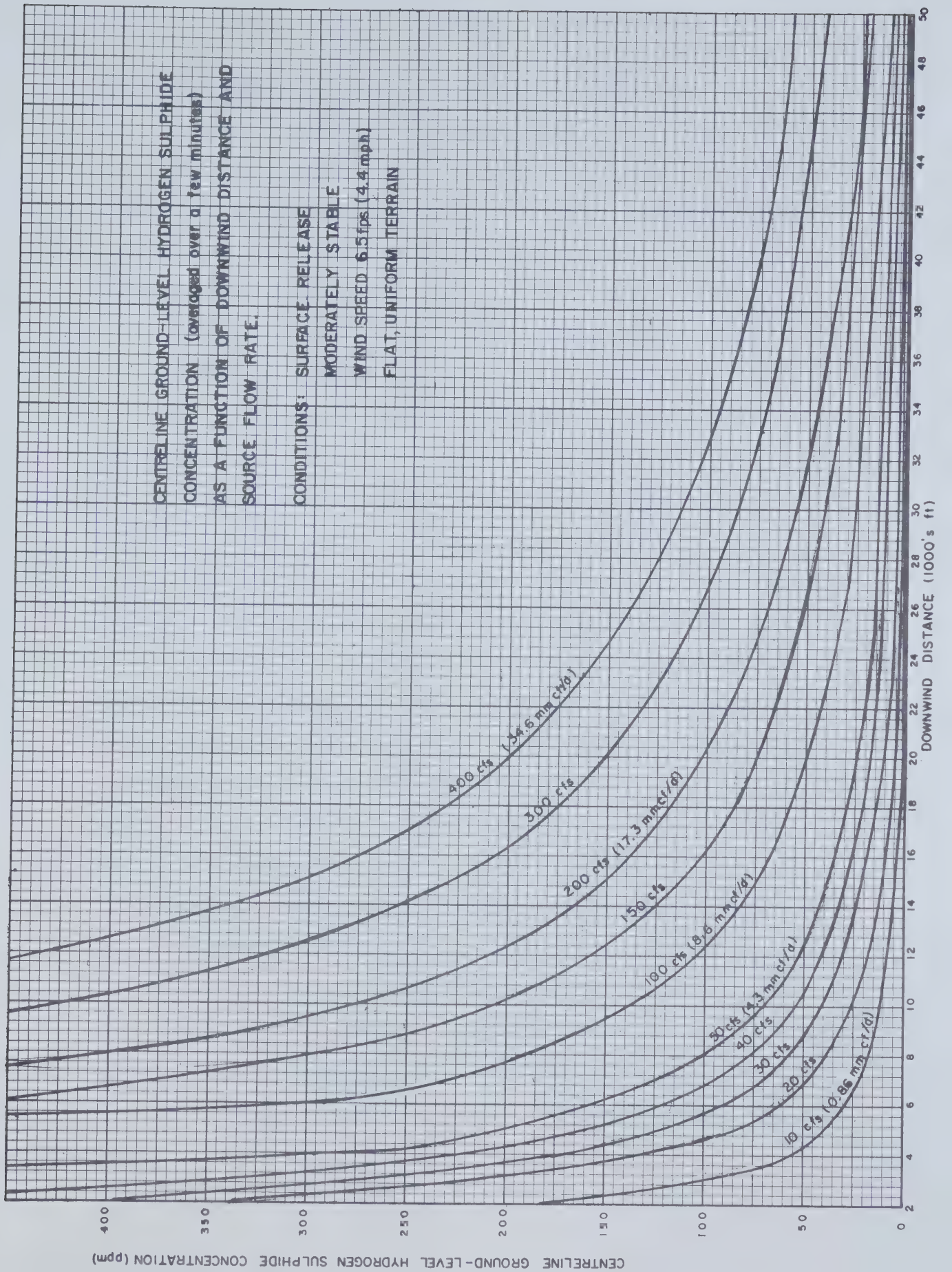
liquid hydrocarbon at Lacq must be a minimum of 200 meters from existing structures within the village limits of Lacq, Artix, Arganon and Mourenx.

The Prefet (Provincial Govenor) will decide on the recommendations from the Mines Inspection Engineer, pursuant to Article 84 of the Mines Regulations, where the flow lines will be prohibited.

4.5 Dispersion Calculations

The Gaussian plume diffusion model for a continuous point source together with the estimation scheme of Pasquill can be used to predict the concentrations of hydrogen sulphide at any location for given atmospheric conditions and constant source flow rate. The worst case is a surface release under Pasquill stability category F (moderately stable) with winds typically 6.5 fps (4.4 mph). The graph on the following page shows the concentrations of hydrogen sulphide (averaged over a few minutes) that would occur at ground level on the plume centreline at various distances for a number of different source flow rates. Because concentration is directly proportional to source flow rate, concentration values for flow rates not given on the graph can be found by simple ratio.

The graph can also be used to predict approximate average concentrations from short period non-continuous releases of given volume ("puffs"), such as those from pipe line ruptures. The procedure is as follows - the appropriate flow rate is the average over the release time and the concentration must then be interpreted as the average concentration during the time interval equal to the release time.


CENTRELINE GROUND-LEVEL HYDROGEN SULPHIDE CONCENTRATION (ppm)
CENTRELINE GROUND-LEVEL HYDROGEN SULPHIDE CONCENTRATION (averaged over a few minutes)
AS A FUNCTION OF DOWNWIND DISTANCE AND SOURCE FLOW RATE.
CONDITIONS: SURFACE RELEASE
MODERATELY STABLE
WIND SPEED 6.5 fps (4.4 mph)
FLAT, UNIFORM TERRAIN
400 c/s (34.6 mm ct/d)
300 c/s
200 c/s (17.3 mm ct/d)
150 c/s
100 c/s (8.6 mm ct/d)
50 c/s (4.3 mm ct/d)
40 c/s
30 c/s
20 c/s
10 c/s (0.86 mm ct/d)
DOWNWIND DISTANCE (1000's ft)
0
50
100
150
200
250
300
350
400
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50

4.6 Examples of Sour Fields Near Urban Development

In order to more fully demonstrate the possible effects of sour gas releases, two example fields have been chosen. Specific study of each field is necessary before a clear idea can be obtained regarding the hazards to any surrounding development. Each field has unique characteristics with respect to flow potentials, capacities of pipe lines, distances of wells and pipe lines from population centres, hydrogen sulphide concentration, safety shut-off equipment, etc. Maps Two and Three provide such a specific study of the Okotoks and Crossfield areas.

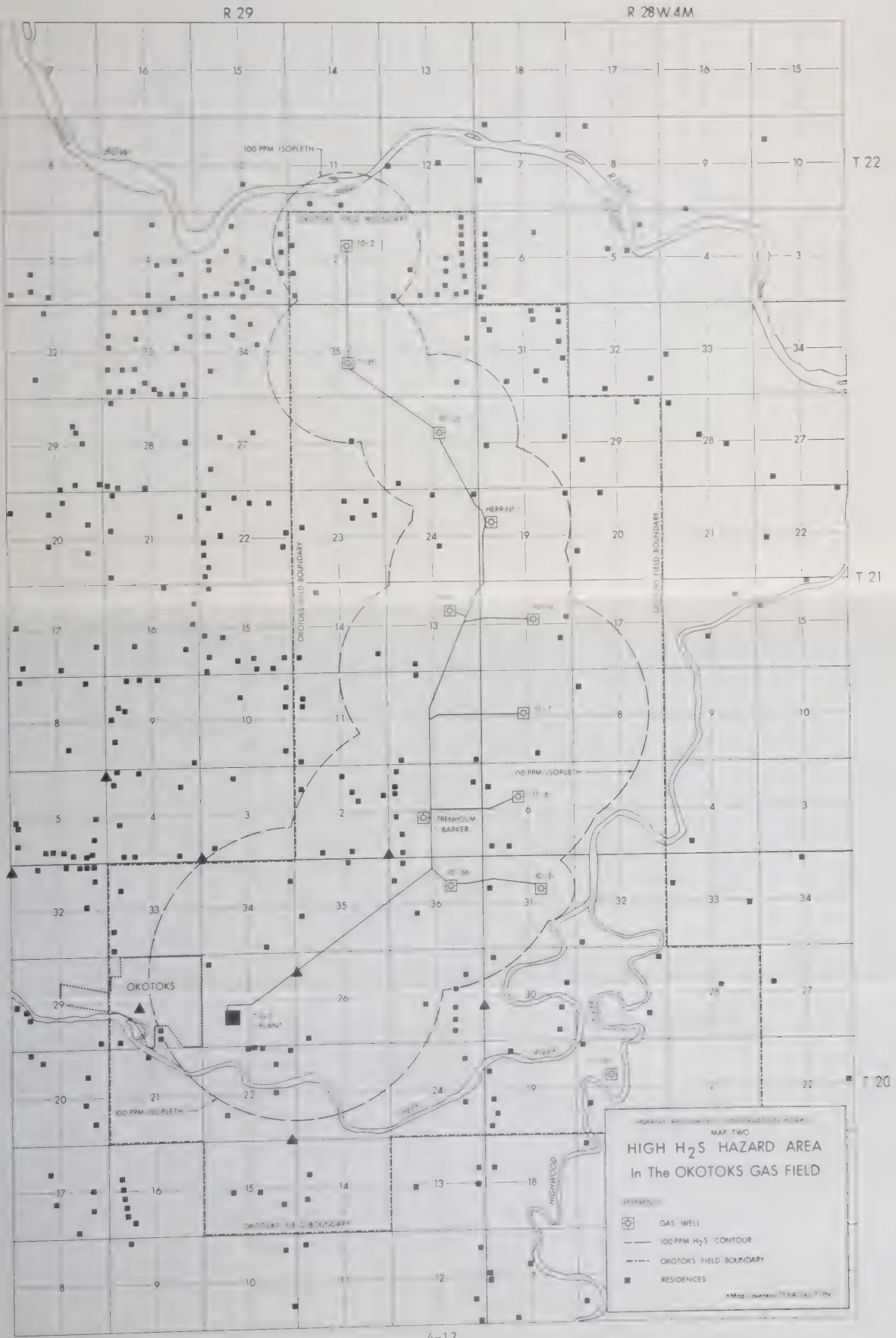
The Okotoks vicinity shown in Map Two is a densely populated semi-rural area southeast of Calgary. The town of Okotoks has a population of about 1,300, and is located less than a mile from a gas processing plant. This plant receives roughly 26 million cubic feet per day of raw gas from the Okotoks field and produces about 400 long tons per day of sulphur. The field itself has 10 producing wells running in a north - south direction. The average hydrogen sulphide concentration of the produced gas is about 34 per cent. The well flow potentials are not high for a gas field, the average being 8 to 10 million cubic feet per day. The gas gathering system is quite compact and operated at a relatively low pressure of 500 pounds per square inch.

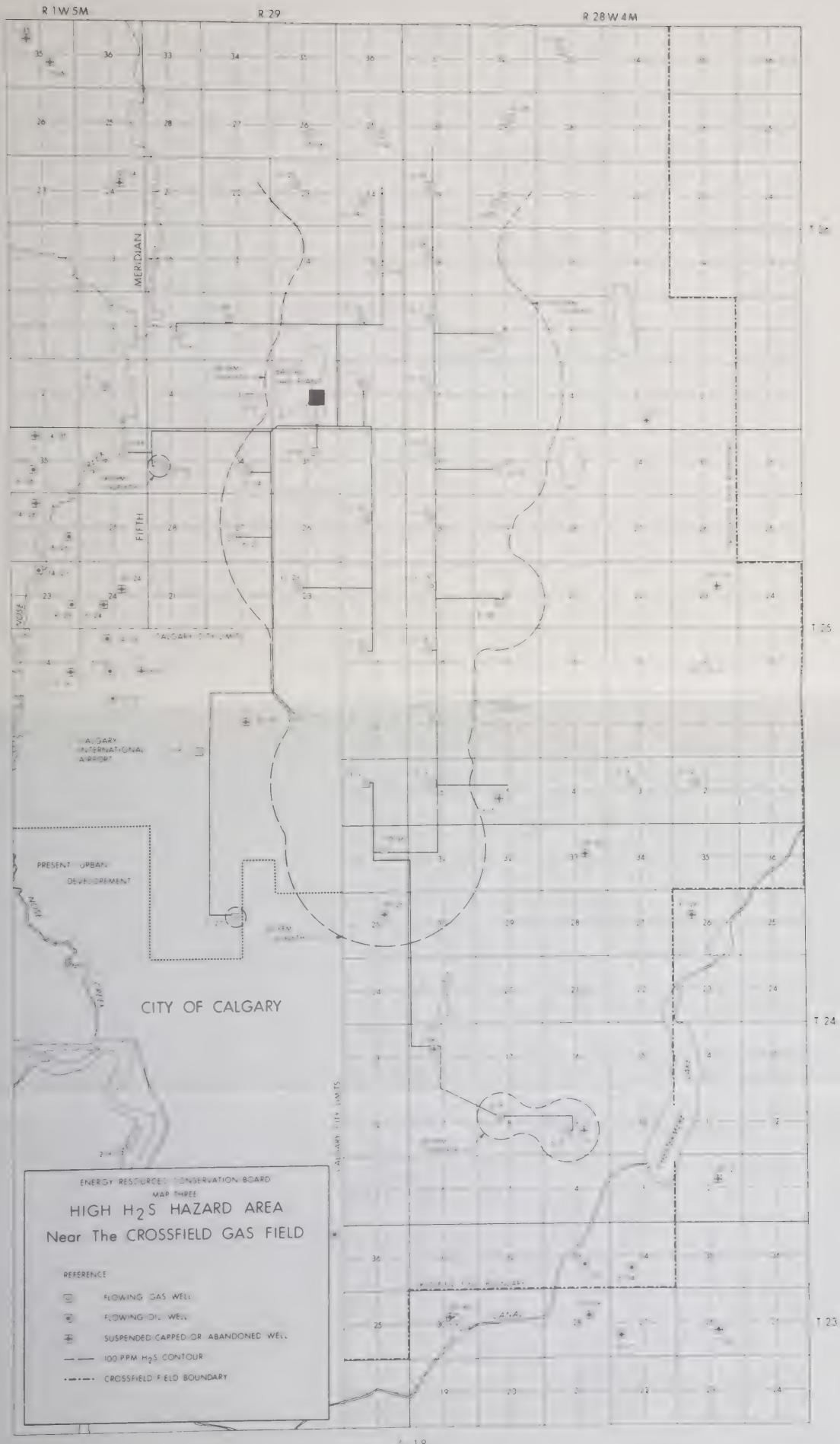
The map of this area has been constructed in an effort to show the behaviour of a hydrogen sulphide escape from a well blowout or a pipe line rupture. The irregular curving line which surrounds the wells and gathering system represents a hydrogen sulphide concentration isopleth of 100 parts per million. The area inside this isopleth could be

subjected to concentrations higher than 100 ppm; the area outside the line would be subjected to concentrations lower than 100 ppm. The concentration contour was drawn by assuming a worst case situation where a well blowout occurred and sour gas was produced at its maximum capacity, or where a pipe line ruptured and released gas at its flowing capacity. Diffusion calculations were performed assuming a surface release of hydrogen sulphide during a period of moderate atmospheric stability and with a wind velocity of 5.5 miles per hour. These calculations should, therefore, provide the worst case for the dispersion of toxic concentrations of hydrogen sulphide. From the map it can be seen that this model predicts over 100 ppm H_2S concentrations throughout most of the Okotoks field. This area contains about 65 rural residences, the gas plant and half the town of Okotoks. Fortunately, the prevailing winds are from the north and west, thus blowing away from the densely populated areas.

Map Three is a similar construction for the Crossfield area north of Calgary. The Crossfield field boundaries in fact encompass a substantial portion of the Calgary city boundary. Gas from most of the wells is gathered and piped to a gas processing plant 3 miles north of Calgary. The plant receives about 319 million cubic feet per day and produces about 1700 long tons per day of sulphur. The average hydrogen sulphide concentration of the Crossfield Wabamun gas is 30 to 33 per cent. The maximum flow capacities of the wells are on the average about twice as high as those in the Okotoks field - about 18 to 20 million cubic feet per day. The gas gathering system is much larger than at Okotoks since almost 50 wells are producing to the plant.

The 100 ppm isopleth can be seen to encroach across the city limit boundary along the northeast corner of the city. In one section it also infringes on present residential development. As the city expands further north and east, more and more development will be exposed to higher risk areas in the event of hydrogen sulphide releases. Both Crossfield and Okotoks sour gas wells are equipped with subsurface shut-off valves and both pipe line systems contain automatic block valve closure in the event of a rupture. These precautions provide a good measure of protection but do not rule out the possibility of a gas escape.


R 29
R 28W4M
T 22
T 21
T 20
100 PPM ISOPLETH
OKOTOKS FIELD BOUNDARY
HERRINT
TRENHOLM
BARKER
OKOTOKS
HIGHWOOD
MAP TWO
HIGH H_2S HAZARD AREA
In The OKOTOKS GAS FIELD
GAS WELL
100 PPM H_2S CONTOUR
OKOTOKS FIELD BOUNDARY
RESIDENCES


R 1W 5M
R 29
R 28W 4M
MERIDIAN
FIFTH
T 25
T 24
T 23
CALGARY INTERNATIONAL AIRPORT
PRESENT URBAN DEVELOPMENT
CITY OF CALGARY
CALGARY CITY LIMITS
ENERGY RESOURCES CONSERVATION BOARD
MAP THREE
HIGH H_2S HAZARD AREA
Near The CROSSFIELD GAS FIELD
REFERENCE
FLOWING GAS WELL
FLOWING OIL WELL
SUSPENDED CAPPED OR ABANDONED WELL
100 PPM H_2S CONTOUR
CROSSFIELD FIELD BOUNDARY

5 TABLES

Table 1

ALBERTA SOUR GAS PIPE LINE BREAKS 1971 - 1974

Year	Total	Reason For Break	Gas Volume Released	Area
1974	6	corrosion	negligible	Kaybob South (10 miles SE of Fox Creek)
		corrosion	negligible	Gold Creek (20 miles S of Grande Prairie)
		corrosion	unknown	Gold Creek
		corrosion	unknown	Hunter Valley (25 miles N of Exshaw)
		corrosion	unknown	Gold Creek
		line cut	567 MCF (13% H_2S)	Lone Pine Creek (10 miles E of Carstairs)
1973	7	corrosion	1500 MCF (3% H_2S)	Rimbey (near Rimbey)
		corrosion	100 MCF (15% H_2S)	Kaybob South
		corrosion	unknown	Burnt Timber (18 miles WSW of Sundre)
		corrosion	negligible	Gold Creek
		corrosion	unknown	Kaybob South
		corrosion	unknown	Jumping Pound (6 miles W of Cochrane)
		corrosion	unknown	Gold Creek
1972	9	line cut	1135 MCF (2% H_2S)	Edson (near Edson)
		corrosion	300 MCF (2% H_2S)	Fenn Big Valley (near Big Valley)
		corrosion	unknown	Redwater (near Redwater)
		corrosion	unknown	Gold Creek
		corrosion	unknown	Jumping Pound West (12 miles W of Cochrane)
		corrosion	300 MCF (30% H_2S)	Olds (near Olds)
		corrosion	negligible	Kaybob South
		corrosion	unknown	Burnt Timber
		corrosion	unknown	Burnt Timber
1971	7	corrosion	40 MCF (30% H_2S)	Olds
		corrosion	750 MCF (8% H_2S)	Gold Creek
		corrosion	500 MCF (30% H_2S)	Olds
		corrosion	unknown	Gold Creek
		corrosion	negligible	Meekwap (30 miles W of Swan Hills)
		line cut	* 3000 MCF (32% H_2S)	Crossfield East (NW of Calgary)
		line cut	1250 MCF (18% H_2S)	Windfall (15 miles W of Whitecourt)

* Burned to SO_2

Table 2

ALBERTA SOUR WELL BLOWOUTS 1970 - 1974

Year	Number	Area	Gas Release Rate MCF/D	Total Volume Released MCF	Cause
1974	0				
1973	1	Malmo	1,000 (4% H_2S)	1,000	Servicing Operations
1972	2	Pine Creek	20,000 (trace H_2S)	100,000	Drilling Operations
		Shekilie	50,000 (1% H_2S)	250,000	Drilling Operations
1971	1	Nevis	10,000 (8% H_2S)	4,000	Servicing Operations
1970	1	Minnehik-Buck Lake	5,000 (1-2% H_2S)	10,000	Equipment Failure

Table 3

SOUR FIELDS NEAR POPULATED SETTLEMENTS

Field	Type	$\%H_2S$	Nearby Development
Acheson	Oil	3%	Edmonton, Stoney Plain
Alix	Oil	18%	Alix
Bantry	Oil&Gas	1%	Brooks
Bashaw	Oil&Gas	4 - 13%	Bashaw
Bellshill Lake	Oil	2%	Alliance
Black	Oil	1 - 3%	Rainbow Lake
Black Diamond	Gas	2%	Black Diamond, Turner Valley, Okotoks
Buffalo Lake	Oil	14 - 19%	Stettler, Alix
Coleman	Gas	19 - 24%	Blairmore, Coleman
Chigwell	Gas	4 - 9%	Ponoka, Morningside
Choice	Oil	5%	Brownfield
Clive	Oil	8 - 12%	Joffre, Alix
Crossfield	Oil&Gas	35%	Calgary, Airdrie, Balzac
Crossfield East	Gas	32 - 35%	Calgary, Balzac, Crossfield, Carstairs
Drumheller	Gas	2%	Drumheller, Munson
Duhamel	Oil	2%	New Norway, Camrose
Eaglesham	Oil&Gas	3%	Eaglesham
Edson	Gas	2%	Edson, Marlboro
Erskine	Oil	8 - 18%	Stettler
Ewing Lake	Oil	1 - 3%	Stettler, Big Valley
Excelsior	Oil	2%	Morinville, Bon Accord

Table 3

SOUR FIELDS NEAR POPULATED SETTLEMENTS

Field	Type	$\%H_2S$	Nearby Development
Fairydell-Bon Accord	Gas	4 - 5%	Redwater, Morinville, Bon Accord
Fenn-Big Valley	Oil&Gas	2%	Fenn, Big Valley
Fenn West	Oil&Gas	2 - 3%	Fenn, Big Valley
Garrington	Oil	10%	Caroline, Sundre
Glen Park	Oil	1%	Calmar, Mulhurst
Golden Spike	Oil	1 - 3%	Devon, Stoney Plain
Greencourt	Gas	1%	Mayerthorpe, Blueridge
Harmattan-Elkton	Oil&Gas	53%	Sundre, Cremona
Haynes	Oil	7 - 23%	Alix, Joffre
Homeglen-Rimbey	Oil	3%	Rimbey
Innisfail	Oil&Gas	4 - 16%	Innisfail, Olds
Irricana	Gas	4%	Irricana, Beiseker, Airdrie
Joffre	Oil&Gas	6 - 11%	Red Deer, Lacombe, Joffre
Jumping Pound	Gas	4%	Bragg Creek, Cochrane
Jumping Pound West	Gas	5 - 8%	Bragg Creek, Radner
Kaybob South	Oil&Gas	2 - 17%	Fox Creek
Leduc-Woodbend	Oil	1 - 6%	Leduc, Devon, Calmar
Lone Pine Creek	Oil&Gas	8 - 15%	Crossfield, Carstairs, Didsbury
Lookout Butte	Gas	3 - 4%	Waterton, Parkbend
Malmo	Oil	4 - 11%	New Norway, Dorenlee
Minnehik-Buck Lake	Gas	2%	Buck Lake, Pendry

Table 3

SOUR FIELDS NEAR POPULATED SETTLEMENTS

Field	Type	$\%H_2S$	Nearby Development
Mikwan	Gas	6 - 9%	Elnora
Morinville	Oil&Gas	1%	Morinville, St. Albert
Nevis	Oil&Gas	1 - 6%	Alix
New Norway	Oil	2 - 4%	New Norway, Dorenlee
Okotoks	Gas	36%	Okotoks, DeWinton, Calgary
Olds	Oil&Gas	10 - 30%	Olds, Didsbury, Carstairs
Pincher Creek	Gas	11%	Parkbend, Drywood, Twin Butte
Quirk Creek	Gas	9 - 13%	Millarville, Turner Valley
Rainbow	Oil	1 - 11%	Rainbow Lake
Rainbow South	Oil	1 - 14%	Rainbow Lake
Redwater	Oil	3%	Redwater, Bruderheim
St. Albert-Big Lake	Oil	1 - 2%	Edmonton, St. Albert
Sarcee	Gas	4%	Priddis, Bragg Creek
Sousa	Oil	2%	Habay
Stettler	Oil	3 - 4%	Stettler
Sturgeon Lake	Oil	9%	Valleyview, Calais
Sturgeon Lake S	Oil	6 - 10%	Valleyview, Calais
Swalwell	Oil&Gas	7 - 12%	Beiseker, Three Hills
Sylvan Lake	Oil	5 - 6%	Markerville, Sylvan Lake
Tehze	Oil	2 - 13%	Rainbow Lake
Thompson Lake	Oil	3%	Alliance
Turner Valley	Oil	4%	Black Diamond, Turner Valley

Table 3

SOUR FIELDS NEAR POPULATED SETTLEMENTS

Field	Type	$\%H_2S$	Nearby Development
Virgo	Oil	1 - 13%	Habay
Waterton	Gas	10 - 33%	Waterton, Pincher Creek
West Drumheller	Oil	2 - 3%	Drumheller, Carbon
Westerose South	Gas	1 - 10%	Rimbey, Westerose
Wildcat Hills	Gas	4%	Cochrane, Radner
Wimborne	Oil&Gas	17 - 29%	Wimborne, Innisfail
Windfall	Gas	4 - 25%	Windfall
Wizard Lake	Oil	1 - 3%	Calmar
Wood River	Oil&Gas	18 - 24%	Ponoka, Bashaw
Yakau Lake	Oil	1%	Edmonton, Stoney Plain, Devon

Table 4

EFFECTS OF HYDROGEN SULPHIDE

Concentration	Physiological Response
up to 20 ppm	- irritant to conjunctive ("gas eye");
over 20 ppm	- severe irritation to eyes;
70 to 150 ppm	- moderate degree of anoxia, followed occasionally by gastric upset and diarrhoea; occasional total collapse ("fall down" effect);
150 to 300 ppm	- eye irritation, chest irritation, vertigo, productive cough, occasionally chest pain simulating "angina"; HAZARDOUS if exposed for more than 1 hour;
300 to 600 ppm	- irrationality, anoxia resulting in death from asphyxia, DANGEROUS if exposed for more than 30 minutes;
over 600 ppm	- may result in pulmonary oedema, can be rapidly FATAL (respiratory paralysis);
over 700 ppm	- FATAL

Sub-Acute - prolonged exposure to concentrations between 20 and 100 ppm may produce:
nausea, gastric disturbance, diarrhoea, productive cough, characteristic smell on breath, disorders of balance mechanism, blurring of vision, neuritis, headache.

Chronic - there is considerable argument as to whether some of the effects reported are due to short-term exposure of susceptible individuals to high concentrations, or to high concentrations. The reports relate to the nervous system and include convulsions, paralysis, meningism, polyneuritis, parkinsonism, mental disturbance, etc.

Table 5

EFFECTS OF SULPHUR DIOXIDE

Concentration	Physiological Response
.03 - 1.0 ppm	- threshold (probably taste);
3 ppm	- easily noticeable odour;
5 ppm	- increased pulmonary flow;
6 - 12 ppm	- immediate irritation of nose and throat, coughing;
20 ppm	- least amount causing eye irritation;
400 - 500 ppm	- immediately dangerous to life, immediate feeling of suffocation;
10,000 ppm	- not breathable, irritating to exposed skin in a few minutes

Acute - sulphur dioxide is an irritant gas: 6 to 12 ppm causes immediate irritation to nose and throat. Three tenths to 1 ppm can be detected by the average individual, probably by taste rather than by odour, and 3 ppm has an easily noticeable odour. About 20 ppm is the least amount irritating to the eyes. One per cent is irritant to moist areas of the skin within a few minutes. Although sulphur dioxide dissolves readily and its inhalation affects chiefly the upper respiratory tract and bronchi, it may cause edema of the lungs or glottis and can produce respiratory paralysis.

Chronic - a period of human exposure of over 2 years to variable concentrations on the order of 30 ppm with occasional peaks of up to 100 ppm was found to have produced a significantly higher than normal incidence of nasopharyngitis, an alteration of the senses of smell and taste, high urinary acidity, and increased fatigue. There was also an extension of the duration of colds, but not a significant change in their incidence.